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**IN-PLACE IODINE FILTER TESTS AT THE
HIGH FLUX ISOTOPE REACTOR**

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HIGH FLUX ISOTOPE REACTOR

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ABSTRACT

A series of in-place iodine filter tests were performed on the charcoal iodine filters at the High Flux Isotope Reactor. The results of those tests indicated that the originally-installed 1/2-in.-thick activated charcoal filters were unsatisfactory. However, the newly-installed 1 1/8-in.-thick impregnated activated charcoal filters perform very satisfactorily. The efficiencies of the new filters are greater than 99.99% for elemental iodine retention and 99.9% for methyl iodide retention.

1. INTRODUCTION

At the High Flux Isotope Reactor (HFIR), charcoal filters are used in air decontamination systems which must prevent releases of radioactive iodine to the atmosphere; and, as integral parts of those systems, the charcoal filters must be reliable components whose efficiencies are known. In order to determine those efficiencies, in-place tests are performed on the filters immediately after their installation and semiannually thereafter.

In general, the efficiency tests as performed at the HFIR involve releasing a radioactive isotope of iodine into a system at a point upstream from the filter unit being tested. Then samples of the air-iodine mixture are withdrawn into small charcoal-filled sampling traps from points upstream and downstream from the filter unit. The radioactive iodine content of the traps is determined by spectral analysis techniques, and each filter unit's efficiency is derived from the amount of iodine collected by the two sampling traps.

2. DESCRIPTION OF HFIR TESTS

2.1 The HFIR Air Decontamination System

The HFIR employs two separate systems for the disposal of radioactive gases and for cleaning air which might become contaminated.¹ As the primary element in the dynamic containment system, the special building hot

exhaust system (SBHE) provides a method for the filtering and subsequent disposal of large amounts of possibly contaminated air. Each of two segments of the SBHE draws 14,500 cfm of air from areas of the reactor building which contain potential sources of radioactive gases. In general, the SBHE system handles large quantities of low-concentration effluents.

The second system, the hot off-gas (HOG) system, is actually a radioactive-gas-disposal unit which handles normal gaseous releases from the subsystems of the reactor such as the cooling system and from experimental facilities. It is designed to handle small amounts of high-concentration effluents and is itself made up of two components: the closed hot off-gas (CHOG) and the open hot off-gas (OHOG) systems. The CHOG serves pressurized facilities, whereas the OHOG serves only unpressurized ones. The maximum flow in each component is 500 cfm.

Air from the SBHE and HOG systems passes through separate underground filter assemblies and is then forced up a 250-ft stack by centrifugal blowers. Each system has three parallel filter assemblies or units (Figure 1). Under normal conditions any two of the assemblies may be used, so that the third is in a standby condition. Manually operated dampers are used to regulate and control the path of flow. The two filter systems are very similar and consist of Fiberglas prefilters, absolute filters, silver-plated copper wool filters, two charcoal iodine absorbers in series, and another bank of absolute filters. Two main differences exist between the two systems. The higher capacity SBHE system has a series arrangement of two banks of twelve single charcoal filters in a 3 x 4 array; the HOG system has only two single filters in series in each unit. The other difference is that the SBHE system has conventional 24-in. x 24-in. pleated-type charcoal filters.* The total flow rates are about 1240 cfm per single filter in the SBHE system and 25 cfm per canister in the HOG system. Air residence times in the charcoal filters are approximately 0.12 sec for the original 2 one-half inch thick SBHE filters and approximately 0.30 sec for the HOG canister type filters.

*The canister type filters in the HOG systems are currently being replaced with the same type of pleated charcoal filters presently in use in the SBHE systems.

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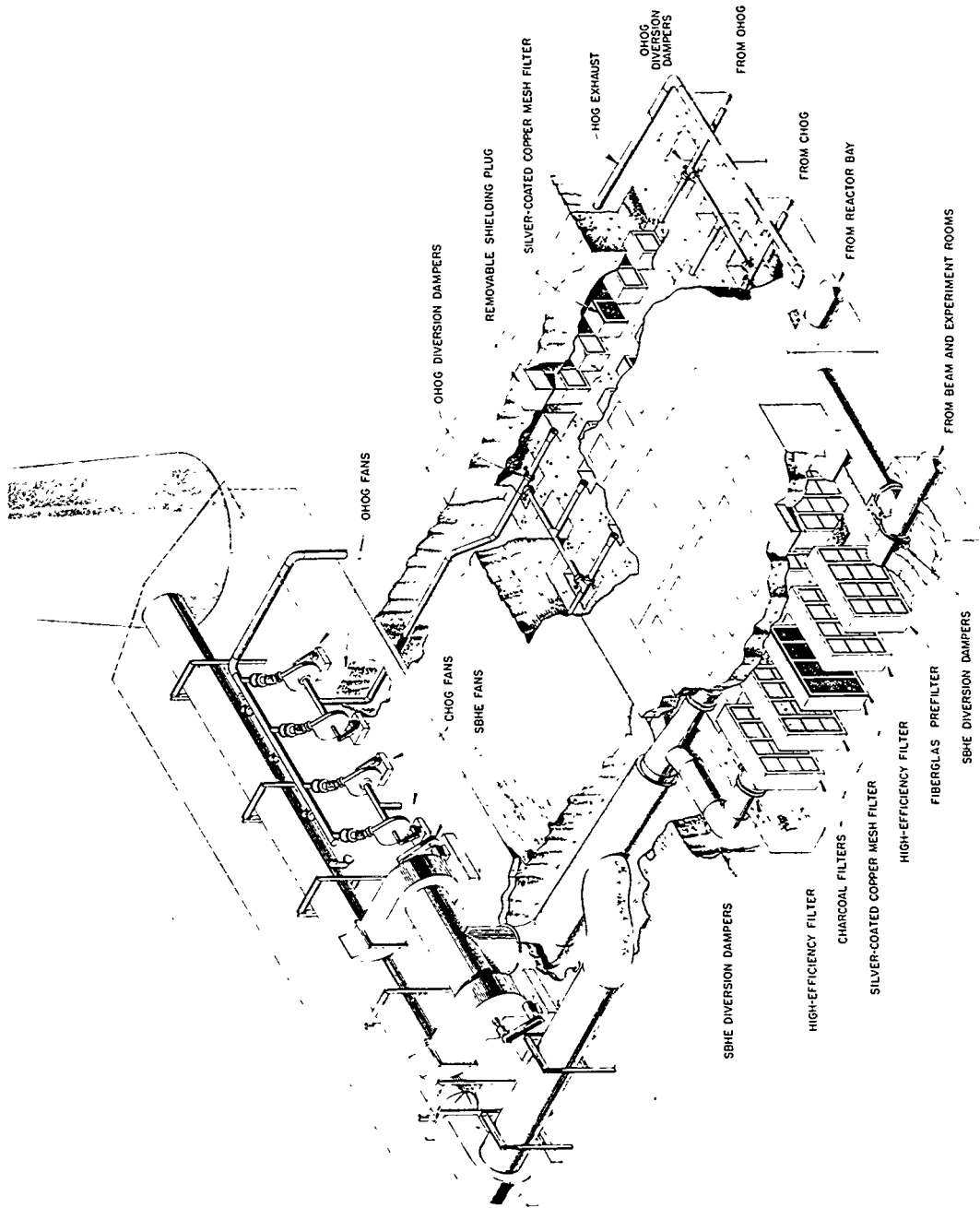


Fig. 1. SBHE and HOG Filter Systems

2.2 Description of Testing Procedures

The HFIR operating limits² require that the iodine filters must be tested immediately after their installation and semiannually thereafter. The tests described herein are those performed after the installation of the filters. Two types of SBHE system filters have been installed and tested. The first type was tested with elemental iodine, whereas the second type was tested with methyl iodide as well as elemental iodine. The first type of SBHE filters had nominally 1/2-in.-thick activated charcoal beds (Barnebey-Cheney Type 513 charcoal) contained between perforated sheet metal plates which were cadmium plated to inhibit corrosion. The HOG filters were canisters having 3/4-in. thick beds of activated charcoal of the same type.

The methods used in testing the filters are well-established³ and have been used extensively for elemental iodine efficiency tests. A minor alteration of the techniques allowed the adaptation of the method to allow testing with methyl iodide.

Iodine-131 was chosen as the radioactive isotope to be used in the tests because, due to its 8.05 day half-life, there would be no necessity for haste in analyzing the traps after they were removed. For the tests on the SBHE filters, 100 mg of stable ¹²⁷I traced with 30 mc of ¹³¹I were used. For the HOG tests, the same amount of carrier was used, but it was traced with only 15 mc of ¹³¹I.

The iodine sources were obtained from the ORNL Isotopes Division as elemental iodine crystals which were contained in a glass ampoule. The ampoule was placed into the apparatus shown in Figure 2. This container served a twofold purpose. It protected the ampoule from breakage during transit to the testing facility, and it served as an apparatus with which to inject the iodine into the system being tested.

The injection tube was mounted in a glovebox which contained the rest of the injection system (Figure 3), and the injection tube was connected to the particular system to be tested. For the conditions existing at the HFIR, it was decided that no exact requirements would be placed on the injection rate except that the iodine should be injected at a reasonably constant rate over a period of about 15 minutes while normal flow and

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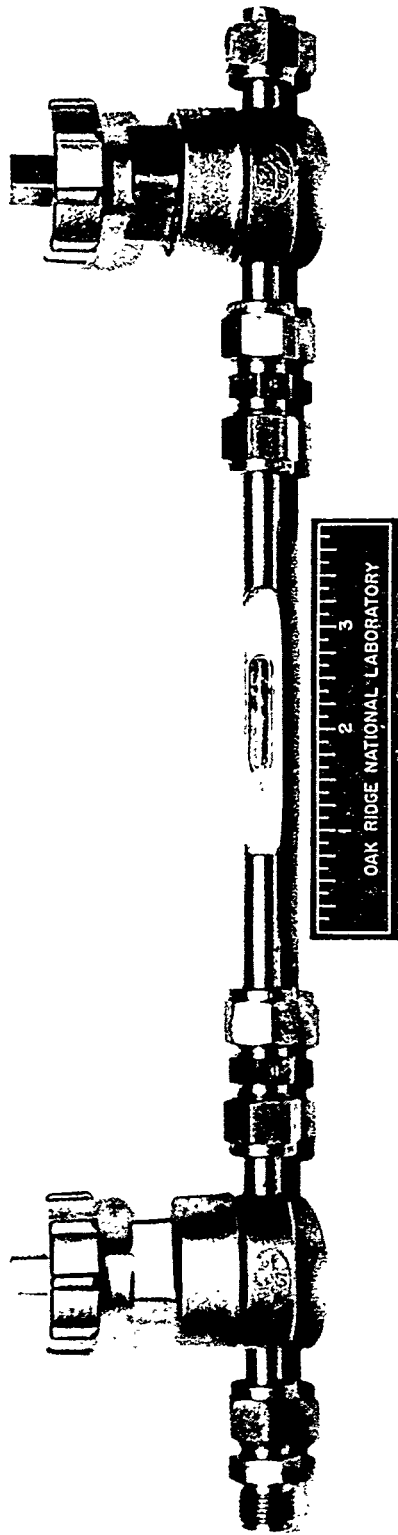


Fig. 2. Injection Tube with Iodine Ampoule

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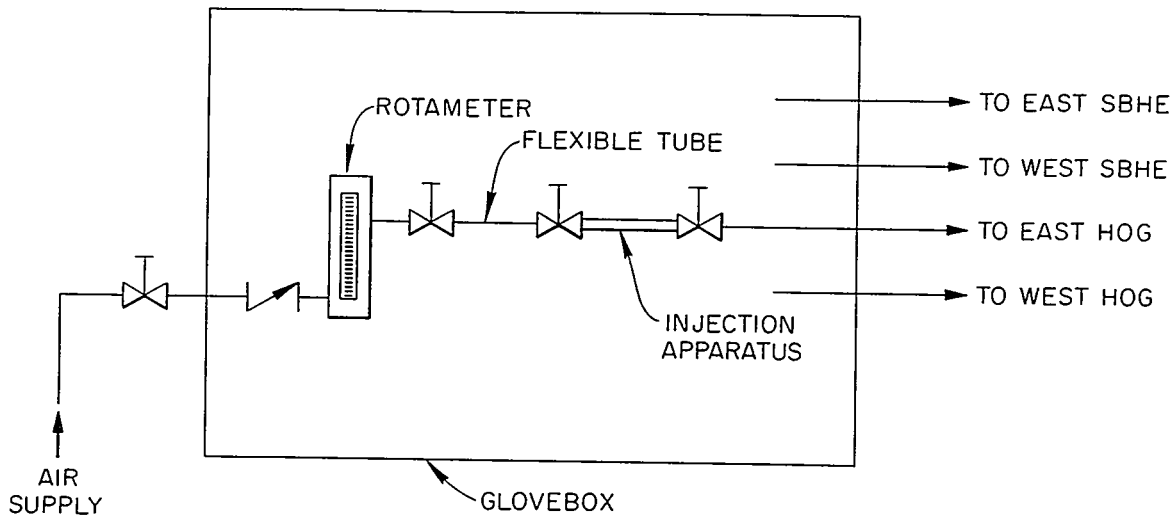


Fig. 3. Iodine Injection System

temperature conditions were maintained in the system being tested. The iodine was injected into the duct at a point 100 ft upstream from sampling points. In order to release the iodine vapors into the system, a small air flow was established through the injection tube. Then the thin-wall tubing of the injection tube was mashed thereby breaking the glass ampoule. The air flow which had been previously established swept the iodine vapors from the crushed ampoule into the system being tested. By gradually varying the air flow rate through the injection tube, the rate of injection was kept fairly constant; and, after the injection period, only an insignificant amount of the iodine remained in the tube.

The air streams were sampled with the sampling traps shown in Figure 4. Activated charcoal was used as the iodine absorber. All of the other parts of the samplers were made of glass and stainless steel with the exception of rubber O-rings used on each end of the glass pipes. The larger traps were used during the tests on the SBHE systems from which 14.5 cfm samples were drawn. The smaller traps were used for the tests on the HOG systems from which 1.5 cfm samples were drawn. Both types of traps were designed to remove at least 99.99% of the iodine in the air passing through them. The glass pipes used for the larger traps were 5-in. ID, and those used for the smaller traps were 2-in. ID. The charcoal bed depth in the traps was approximately 3 in., but the traps were prepared specifically so that the same charcoal density was attained in all the traps. It was assumed that the efficiencies of the upstream and downstream sampling traps were identical.

In both systems the samples were withdrawn immediately upstream and downstream from the filter assemblies through the traps' sampling tubes which extended to the centerline of the duct. Vacuum with which to withdraw the samples was provided by the HOG system. When testing the HOG system, the segment not being tested provided the vacuum. Flow rates through the traps were measured with calibrated rotameters, and identical flow rates were maintained through the upstream and downstream traps. It was assumed that complete mixing of the air and iodine had taken place upstream from the first sampling point and that the samples withdrawn were of the average concentration. Samples were withdrawn simultaneously and continuously during the entire injection period and for approximately two

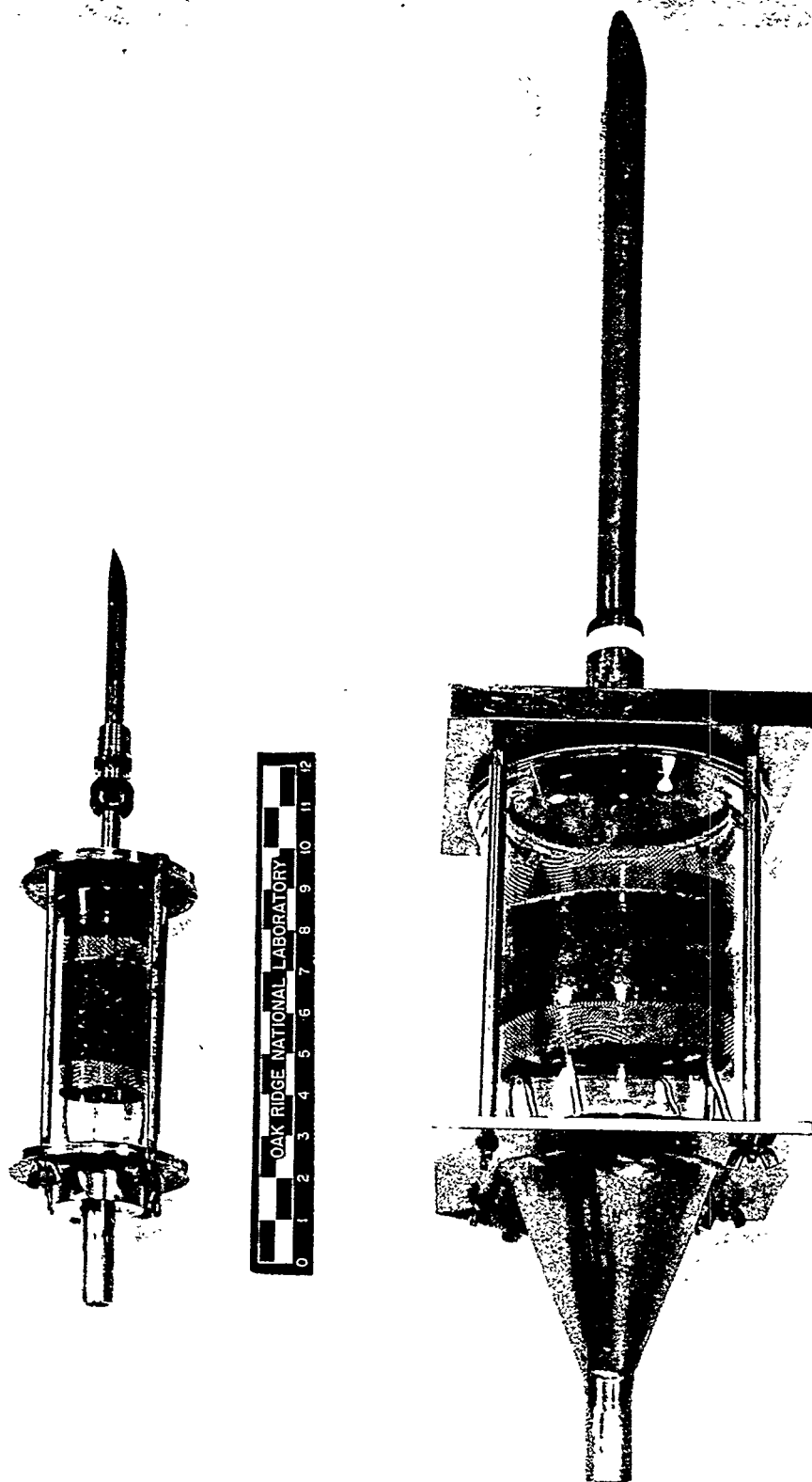


Fig. 4. Sampling Traps

hours after the injection was begun. Thus any iodine that came off the filters during this two hours was detected in addition to that which passed through the filters during the injection period.

After the sampling period, the traps were immediately removed and disassembled for analysis. After their removal, the traps were sealed airtight; so, the possibility of any iodine escaping from the traps was minimized. To prepare the traps for analysis, the charcoal was removed from the traps and divided into smaller quantities. The insides of the traps were swabbed with NaOH solution to remove any charcoal dust and iodine that might have deposited on the surfaces. The small charcoal samples and the swabs were placed in petri dishes and counted separately with a gamma spectrometer. The radioiodine content of each individual sample was then determined, and the total for the entire trap was obtained by summing the activities of the components. The samples were usually counted when they were prepared or as soon thereafter as possible. In either case, the samples remained sealed airtight so that the only loss mechanism was the decay of the radioiodine. The amount of time elapsed between the actual test and the counting of the samples did not seem to affect the results significantly as long as the count rate in the samples from the downstream trap remained fairly high.

The raw data from the tests on one of the banks of 1/2-in. SBHE filters are presented in Table 1. These typical data are indicative of the relative magnitude of the various quantities.

Table 1. Data from a Typical Analysis

	^{131}I Content of Upstream Trap (dis/min)	^{131}I Content of Downstream Trap (dis/min)	Background (dis/min)
Test 1	6.012×10^7	6.573×10^5	80
Test 2	5.082×10^7	4.800×10^5	58

2.3 Tests on 1/2-in-Thick Filters

The results of the first series of tests are given in Table 2. The indicated decontamination factor (DF) is related to the efficiency by the following equation:

$$DF = \frac{1}{1 - \text{Efficiency}}$$

Table 2. Results of First Tests

System Tested	Iodine Removal Efficiency (%)	Decontamination Factor
East SBHE*	99.06	106
Standby SBHE*	99.62	260
West SBHE*	99.40	166
East HOG**	99.98	4120
Standby HOG**	99.98	3700
West HOG**	99.99	8200

*1/2-in.-thick pleated-type filters.

**3/4-in.-thick canister-type filters

Upon examination of the results of these tests, it was concluded that the HOG filter systems performed satisfactorily and that no modification or further testing of those systems was necessary. However, the fact that the efficiencies of the SBHE systems' filters were lower than anticipated caused some concern, for it was felt that their efficiencies should be on the order of 99.8% or greater. In order to check the results of the first tests, another test was performed on the east bank of SBHE filters. The results of this test were:

Efficiency = 98.9%

DF = 92

In order to determine the cause of the low efficiencies, the filters were removed from their compartment and inspected. Several large openings were observed around the framework of the filters, so a portion of the air stream had been bypassing the filters.

The leaks around the filters were sealed, the filters were replaced in their compartments, and more tests were performed. The results indicated in Table 3 were obtained from those tests. As may be noted, sealing the leaks improved the systems' efficiencies somewhat, but they were still less efficient than desired.

Table 3. Results of Second Test of 1/2-Inch-Thick Filters

System Tested	Iodine Removal Efficiency (%)	Decontamination Factor
East SBHE	99.65	263
Standby SBHE	99.75	397
West SBHE	99.77	442

In order to determine whether or not the thickness of the charcoal was insufficient, comparison tests were run on two 1/2-in.-thick HFIR charcoal filters and two 3/4-in.-thick filters which were available. Charcoal specifications for the 3/4-in.-thick filters were the same as those for the 1/2-in.-thick filters. Identical conditions were maintained while running the tests on the two types of filters, and the results shown in Table 4 were obtained.

Table 4. Results of Comparison Tests

System Tested	Iodine Removal Efficiency (%)	Decontamination Factor
1/2-in. Filters	99.67	303
3/4-in. Filters	99.94	1730

2.4 Tests on 1 1/8-in.-Thick Filters

Due to the low efficiencies of the 1/2-in.-thick filters and a study regarding the methyl iodide hazards at the HFIR,⁴ it was decided to replace the 1/2-in.-thick filters with a new set of thicker filters. The new filters are made of perforated stainless steel with an impregnated activated charcoal filler (MSA 85851) which is nominally 1 1/8-in. thick. The air residence time in the charcoal is approximately 0.28 sec for these filters.

Two types of iodine retention tests were performed on the new filters. They were first tested for elemental iodine retention using the same procedures that were used while testing the sets of 1/2-in.-thick filters. In addition, the new filters were tested for methyl iodide retention. The sampling and analytical techniques for the methyl iodide tests were identical to those used in the elemental iodine tests, but the injection procedure had to be modified somewhat. The same quantity of iodine was used as in the elemental iodine tests except that it was in the form of methyl iodide and was contained in a stainless steel U-tube.

To obtain a fairly uniform release rate, the U-tube was installed in the injection apparatus, a delay tank was connected to the downstream side of the U-tube, and the tank was connected to the system to be tested. A very small air flow was established through the U-tube so that methyl iodide vapor moved into the delay tank and then slowly flowed from the tank into the system being tested.

During the test on the west SBHE filters, the elemental iodine and methyl iodide tests were performed simultaneously by using elemental iodine-131 and methyl iodide-130. By using the two isotopes, only one injection and sampling was necessary. Spectral analyses of the samples allowed one to distinguish between the ^{130}I and ^{131}I isotopes during the analyses. The results of the test are presented in Table 5.

Table 5. Results of Tests on Stainless Steel Filters in West SBHE

Type of Test	Iodine Removal Efficiency (%)	Decontamination Factor
Elemental iodine	98.55	69
Methyl iodide	47.37	1.9

Considering these results, it was obvious that something was wrong with the system because the original, thinner filters had performed more efficiently than these.

The filters were inspected in place, and no leaks were evident. They were then removed from their compartments, disassembled, and opened for examination. Upon removal of the tops of the filters, the problem was

seen immediately; the charcoal had settled to such an extent that numerous air gaps had formed at the top of the filters. A typical settled filter is shown in Figure 5. The filters were refilled with the same type of charcoal, reinstalled in their compartments, and retested both for elemental iodine and methyl iodide retention. The results of the tests on all the SBHE systems are given in Table 6.

Table 6. Results of Tests
On Stainless Steel SBHE Charcoal Filters

Systems Tested	Iodine Removal Efficiency (%)		Decontamination Factor	
	Elemental	Methyl	Elemental	Methyl
East SBHE	99.994	99.97	17,300	3,580
Standby SBHE	99.994	99.97	16,100	3,850
West SBHE	99.995	99.98	20,300	4,200

The absolute accuracy of the results of this last series of tests is somewhat questionable, for the activities in the downstream samplers were quite low. However, the results are definitely conservative, and the systems are at least as efficient as these results indicate.

3. CONCLUSIONS

These tests illustrate that the filters now installed in the SBHE system perform quite satisfactorily for both elemental iodine and methyl iodide retention. However, tests that have been performed give no direct indication whether the increased efficiency for retention of elemental iodine is due to the increased charcoal bed thickness, the use of MSA-85851 impregnated charcoal, or the combination of these two factors. It may well be that 1 1/8-in.-thick filters using the Barnebey-Cheney Type 513 charcoal would perform comparably with the MSA charcoal filters. However, a recent study⁴ indicated definitely that the MSA charcoal was more efficient for removing methyl iodide under the conditions existing at the HFIR.

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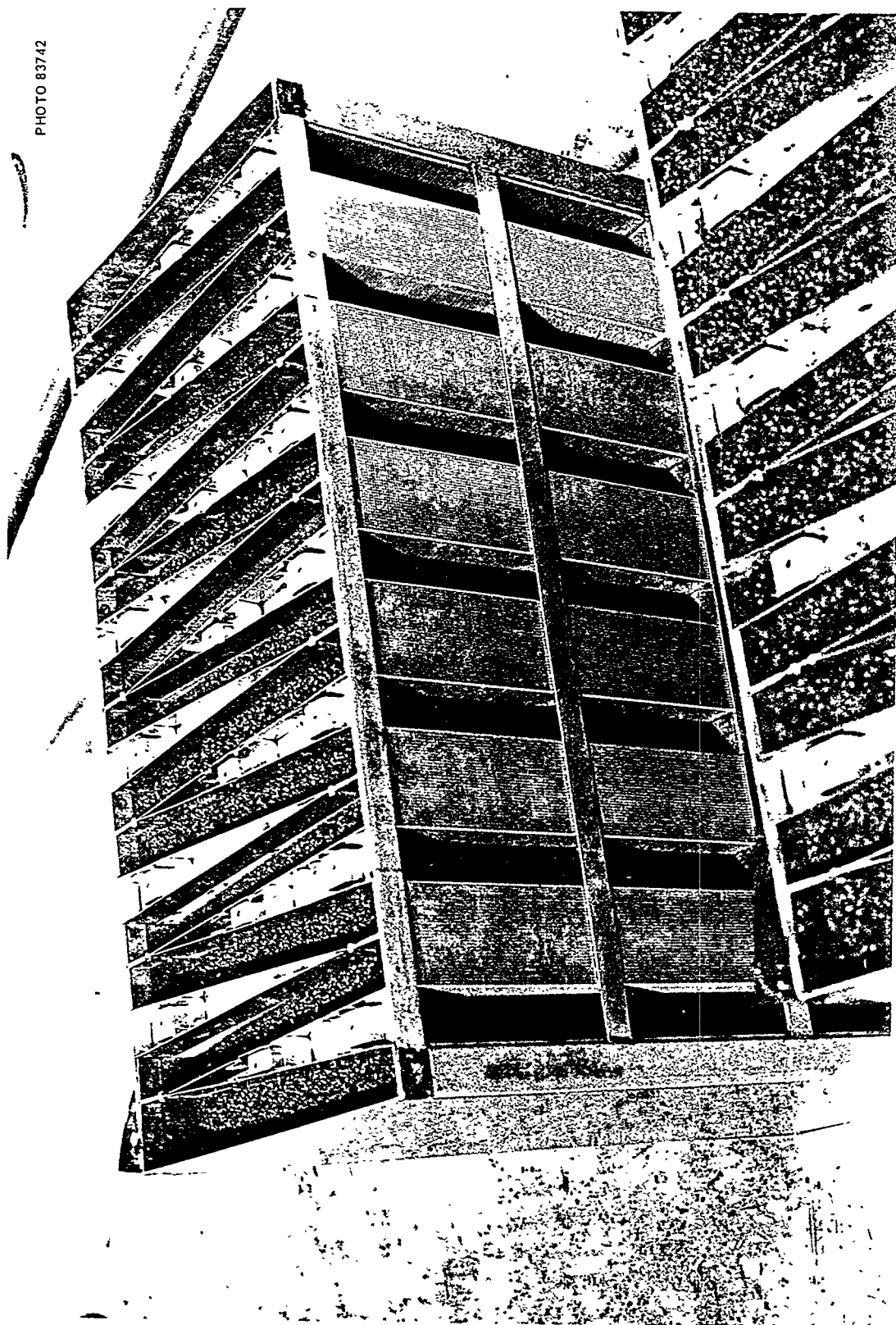


Fig. 5. An SBHE Filter in Which Charcoal Had Settled

It, of course, still remains to be seen how the filters will behave as the charcoal ages; but the semiannual tests should indicate satisfactorily the condition of the filters during prolonged use.

At the present time, the HOG canister-type filters are being replaced with the pleated-type 1 1/8-in.-thick filters, so that all of the filters will be identical. As soon as the new HOG filters are installed, they will be tested in place for elemental iodine and methyl iodide retention.

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